Energy Exchange℠ | Better Buildings® SUMMIT

AUGUST 21-23, 2018 • CLEVELAND, OHIO

Making a Splash

Targeting Water Measures for Maximum Impact

Cutting Water Waste

DOE Began Working with Partners on Water Goals in 2015

- Saving water saves energy
- Cuts costs
- Improves resiliency
- Demonstrates environmental stewardship

Better Buildings Water Savings Initiative

- More than 40 Partners
- 9 Goal Achievers
- More than 6 billion gallons cumulative water savings
- 30+ solutions to common barriers, such as:
  - Making the business case for water savings
  - Tracking and managing water data

Partners with Greatest Water Savings

Savings Since Baseline Year

Shari's Café & Pies*	**37%**
Staples*	**35%**
Anthem, Inc.*	**31%**
United Technologies Corporation (UTC)	**19%**
Alachua County Public Schools, FL	**19%**
Tenderloin Neighborhood Development Corporation	**17%**
Atlanta, GA*	**15%**
Intuit	**13%**
State of North Carolina	**13%**
Hillsboro, OR	**11%**

**Water goal achiever*

betterbuildingssolutioncenter.energy.gov/challenge/water-savings

Better Buildings
U.S. DEPARTMENT OF ENERGY

Speakers

- Sachin Nimbalkar, Oak Ridge National Laboratory
- Hakon Mattson, Anthem Inc.
- Otto Van Geet, National Renewable Energy Laboratory

Sachin Nimbalkar

Oak Ridge National Laboratory

Plant Water Profiler (PWP) Tool for Industry

Sachin Nimbalkar
Mini Malhotra
Kristina Armstrong
Asha Shibu
Oak Ridge National Laboratory

Rochelle Samuel
Saint Gobain

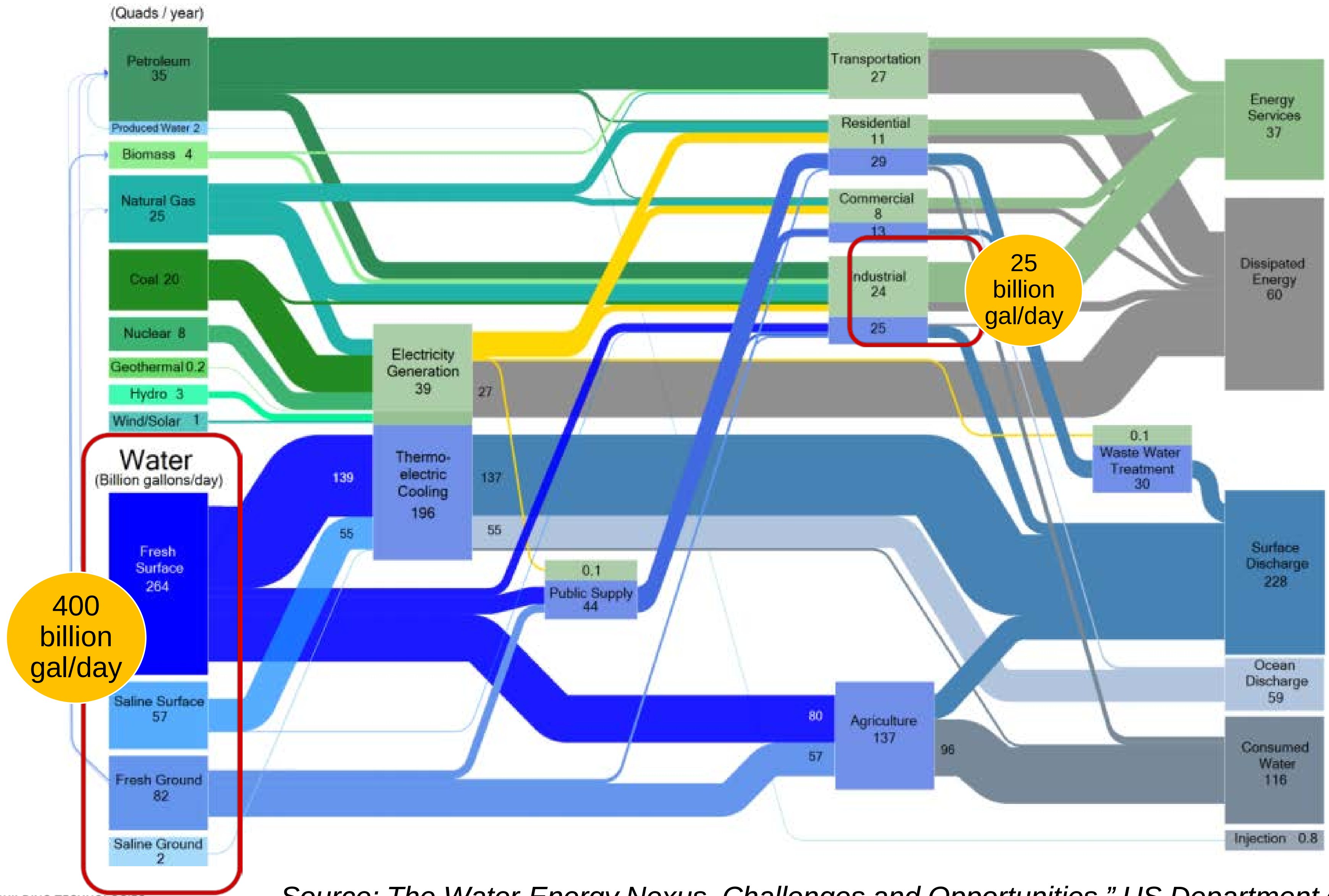
T20-S8a – Making a Splash Targeting Water Saving Measures for Maximum Impact

Better Buildings Summit 2018
August 23, 2018 – 8:30 to 10:00 am
Cleveland, OH

Outline

- Need for Water Conservation/Efficiency in Industry
- Benefits of Water Conservation/Efficiency in Industry
- Plant Water Profiler (PWP) Tool Overview
- PWP Tool Methodology
- Significance of PWP Results for a Facility
- PWP Tool Demo
- Case Study – Beta Testing
- Summary
- Limitations and Future Work

Need for Water Conservation/Efficiency in Industry



Source: The Water-Energy Nexus, Challenges and Opportunities," US Department of Energy, June 2014.

Benefits of Water Conservation/Efficiency in Industry

Cost savings and operational improvements	Cost of **purchasing** water for facility
	Cost of **material** for water treatment
	Cost of **discharge** water treatment
	Cost of energy for **heating and cooling** water
	Cost of energy for **pumping** water
Reduce business risks	Business Interruption– **Risk of disruption** of water supply in supply chain
	Regulatory- Risk of **increased government regulation** on water use
	Access to capital- Risk of financial institution adopting **stricter lending and investment** based on water uncertainties

Plant Water Profiler (PWP) Tool Overview

- The Plant Water Profiler (PWP) tool (US Department of Energy, 2018) is a comprehensive tool designed for use by manufacturing plants to help their sustainability teams:

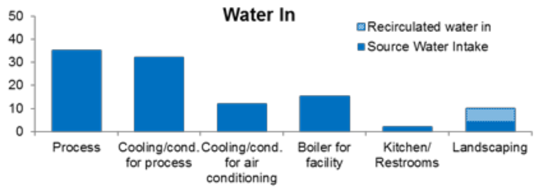
1. Understand the procurement, use, and disposal of water in their plants;
2. Be cognizant of the true cost of water, including the costs associated with water procurement, treatment, and consumption and wastewater disposal; and
3. Identify opportunities to reduce water use and achieve associated cost savings.

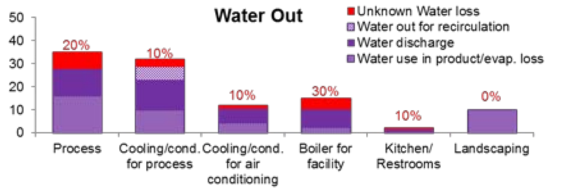
Other Available Tools and Their Limitations

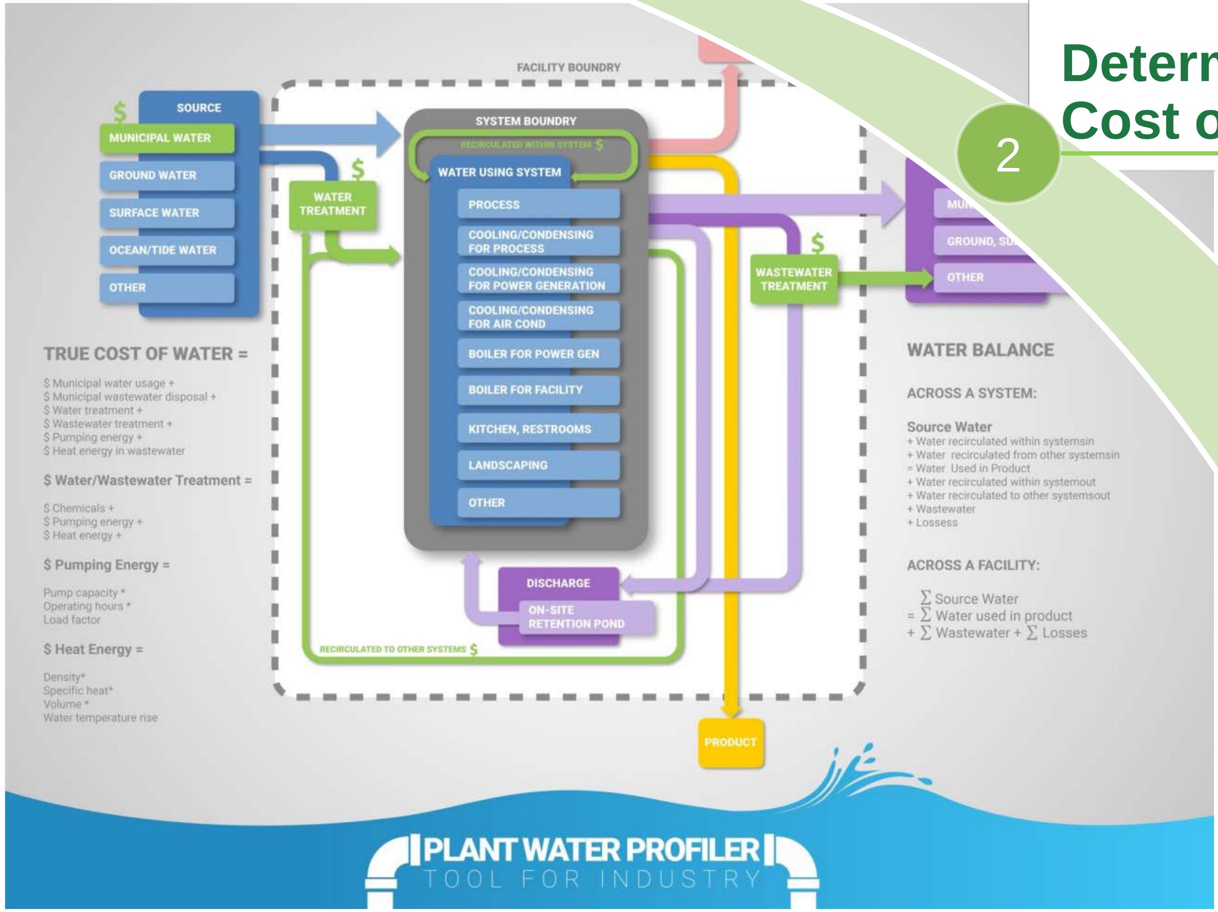
Name	Sector/Spatial Scale	Purpose	Inputs	Output	Citation
Cummins Water Tool	Industrial facility (engine and power systems)	True cost of water	Facility water and energy use data, costs	True cost by system and cost category	(Dhennin, Personal Communication, 2017)
Colgate-Palmolive True Cost of Water Toolkit	Industrial facility	True cost of water	Facility water data, costs	True cost of water	(Colgate-Palmolive, 2014)
Veolia True Cost of Water tool	Industrial facility	True cost of water, water risk analysis	Facility water data, costs	Probability versus potential economic impact of each risk	(Veolia, 2014)
BIER True Cost of Water toolkit	Industrial facility (beverage industry)	True cost of water	Facility water data, costs	True cost by system and cost category	(BIER, 2015)
PepsiCo ReCon Tool	Industrial facility	True cost of water	Facility water data, costs	True cost of water	(Dallbauman, 2012)
Water Footprint Assessment Tool	Agricultural, industrial; global, country or basin level	Water footprint of processes and products	Water use and production data	Water footprint impact index, possible water footprint reduction targets and water footprint component	(Water Footprint Network, n.d.)
WBCSD Global Water Tool (GWT)	Country level (GWT–WRI)	Water risk analysis	Facility GPS location, facility water data	Water inventory, reporting indicators, global map of facilities overlaid with water-related map layers	(WBCSD, 2015)
WRI India Water Tool	Watershed level (GWT–University of New Hampshire); No distinction between industries	Water risk analysis	Facility GPS location, facility water data	Map showing areas of greatest groundwater availability and quality risks, reporting indicators, Ramsar- designated sites	(WRI, 2015)
GEMI Collecting the Drops: A Water Sustainability Planner tool	Industry, community, natural resource (facility-wide)	Develop water sustainability strategies	Facility water use, impact of operations on the regional water supply	Potential water reduction; water risk level	(GEMI, 2007)
GEMI Connecting the Drops Toward Creative Water Strategies	Industrial	Water risk analysis; develop water strategy	Facility water use data, business operation	Guide for developing and implementing water strategies	(GEMI, 2002)
GEMI Local Water Tool	Industrial (site and operation-specific)	Water risk analysis	Facility water use and discharge data	Water use metrics, external impact and risk levels	(GEMI, 2015)
WWF Water Risk Filter	Country or basin level; 35 industry sectors	Water risk analysis	Facility GPS location, type of industry, 30-question survey on physical, regulatory, and reputational data	Global map of facilities overlaid with water-related map layers. Physical, regulatory, and reputational risk at the basin and company level	(WWF, 2012)
Ecolab Water Risk Monetizer	Industrial	Water risk analysis	Facility water data, business information,	Various metrics for incoming and outgoing water risks	(Ecolab, 2017)
WRI Aqueduct Tool	Administrative district or subdistrict level; No distinction among industries	Water risk analysis	Facility GPS location	Global map of facilities overlaid with a combination of 12 global water risk indicators	(WRI, 2014)

Plant Water Profiler (PWP) Tool: Methodology

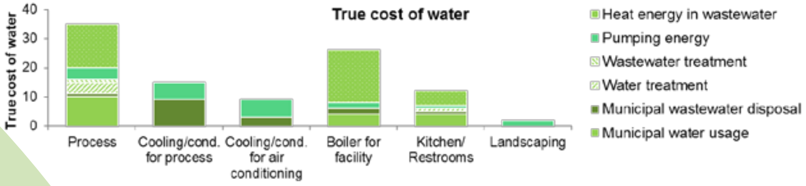
1 Baseline Water Use and Water Balance



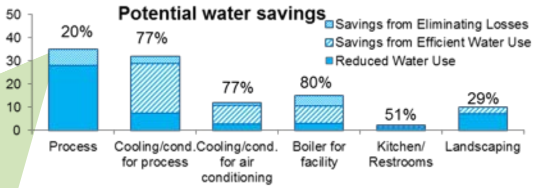




2 Determine True Cost of Water

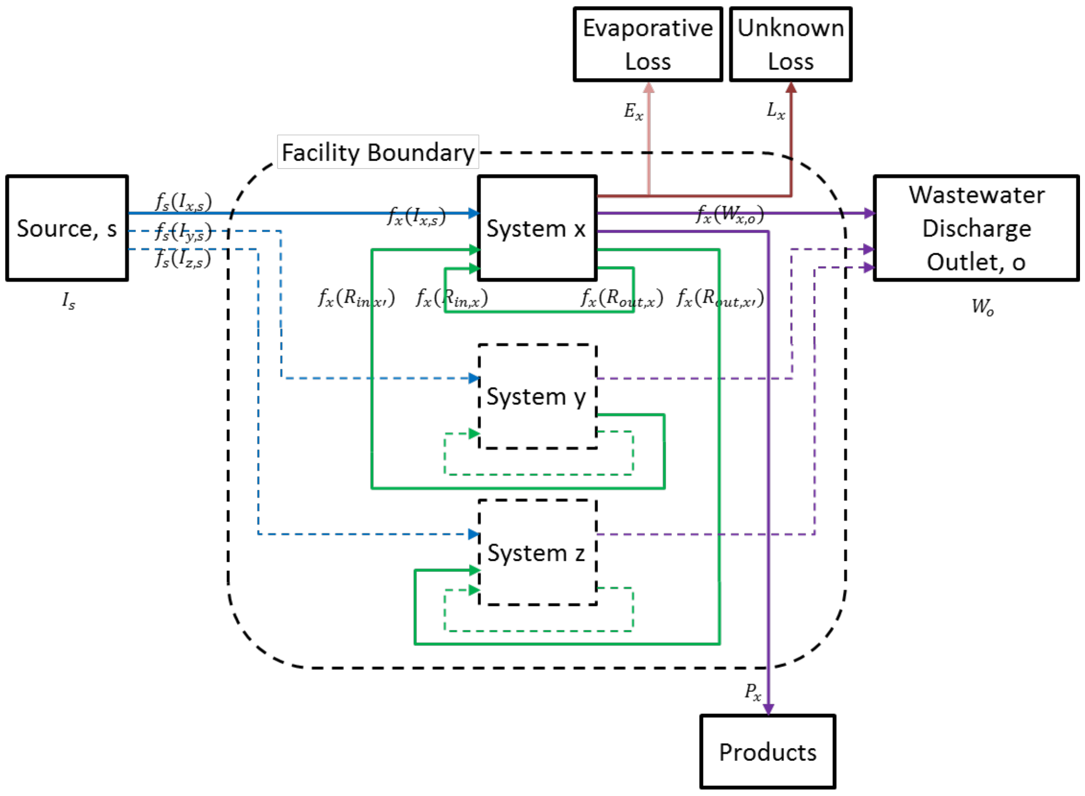


3 Identify Water Efficiency Opportunities

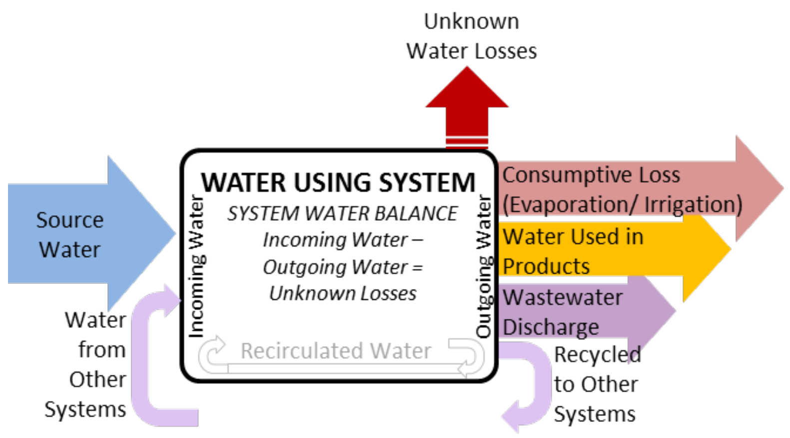


OAK RIDGE National Laboratory | BUILDING TECHNOLOGIES RESEARCH AND INTEGRATION CENTER

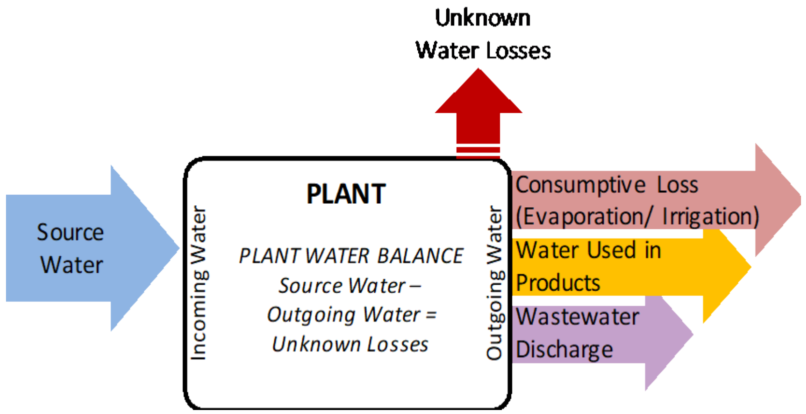
Step 1 - Water Flow Model and Water Balance



Water Flow Model

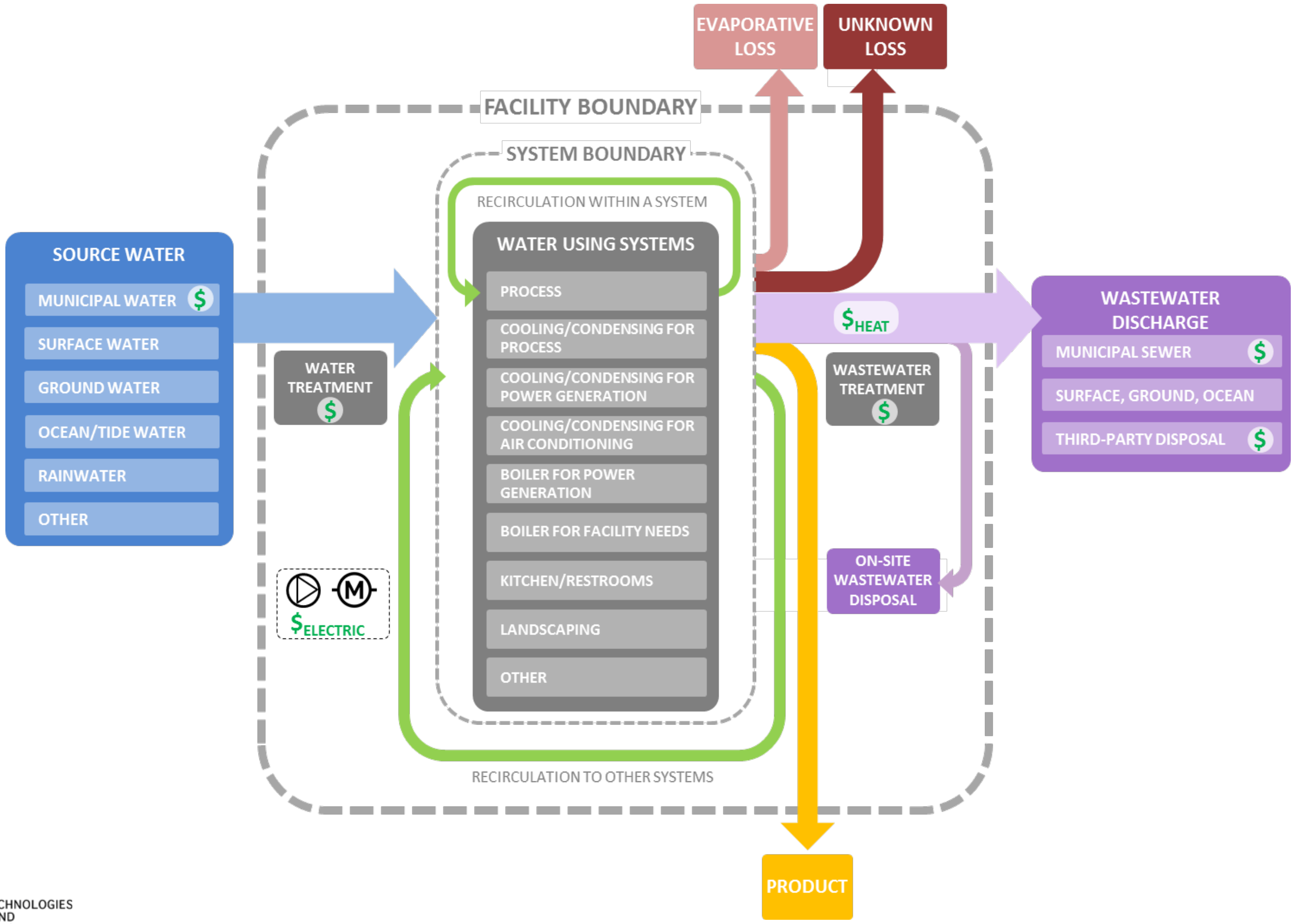


System Water Balance



Plant Water Balance

Step 2 - Water Flow Diagram with True Cost Components



Step 3 - Identify Water Efficiency Opportunities

- User answers system-specific questions to evaluate water efficiency status on system-level and to identify potential opportunities.

Water Saving Opportunity Level	
Process	+
Cooling/condensing for process	--
High = No system assessment completed in the last three years/ Don't know	
Medium = System assessment completed but little or no implementation completed in the last three years	
Low = System assessment completed and substantial implementation completed in the last three years	
Cooling/condensing for air conditioning	+
Boiler for Facility	+
Kitchen and Restrooms	+
Landscaping	+

Scorecard	Response
Process	
Cooling/condensing for process	
Has once-through cooling water been eliminated with the use of chillers, cooling towers, or air-cooled equipment?	No
Has blow-down/bleed-off control on cooling towers been optimized?	No
Is treated wastewater (or other sources of water for cooling tower make-up) reused where possible?	No
Are cycles of concentration for cooling towers maximized through efficient water treatment?	No
Is a conductivity controller installed on each cooling tower?	No
Have cooling towers been equipped with overflow alarms?	No
Are high-efficiency drift eliminators in use?	No
Cooling/condensing for air conditioning	
Boiler for Facility	
Kitchen and Restrooms	
Landscaping	

Significance of Results for a Facility

Water Use Intensity

- Establishes baseline to track water use and savings over the years
- Allows comparison with industry average (motivation to conserve/save)

Plant & System Water Balance

- Quantifies unknown water losses to be eliminated (low-cost/no-cost measure)

True Cost of Water

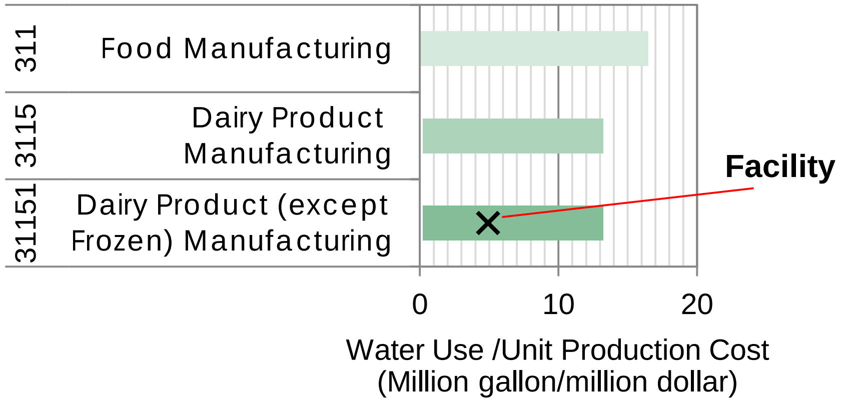
- Reveals hidden costs of using water
- Identifies cost-intensive systems to help prioritize measures, accordingly

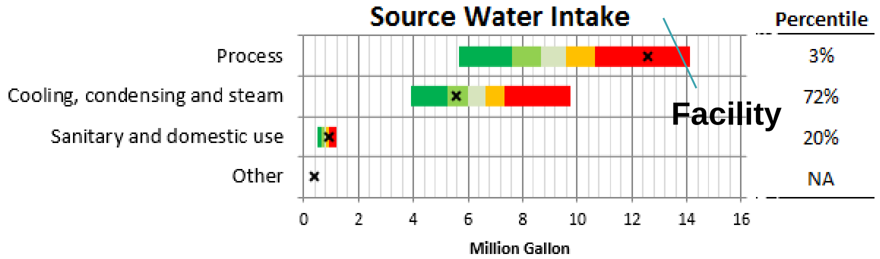
Savings from eliminating losses and maximizing recirculation

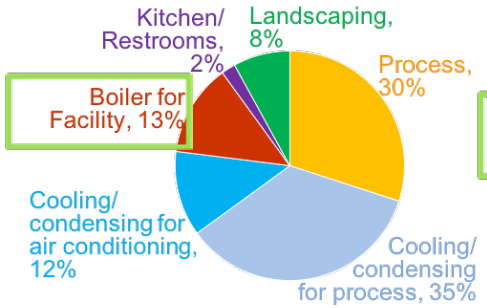
- Provides realizable saving estimates from low-cost/no-cost measures

Recommendations

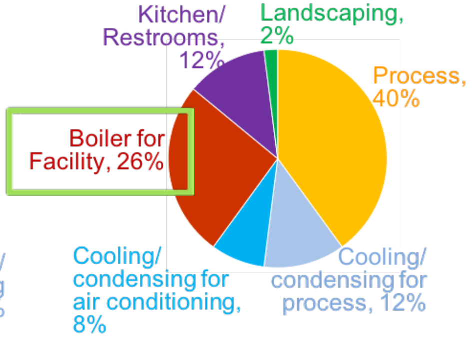
- Steps to follow to save water and associated costs







Source Water Intake



True Cost of Water

Case Study – Beta Testing

Facility Description & PWP Tool Results*

Manufacturing Facility

- CertainTeed – Saint Gobain North America's (SGNA) siding products manufacturing facility
- Produces millions of sqft of polymer siding using **injection molding process**.

Plant's water consuming systems

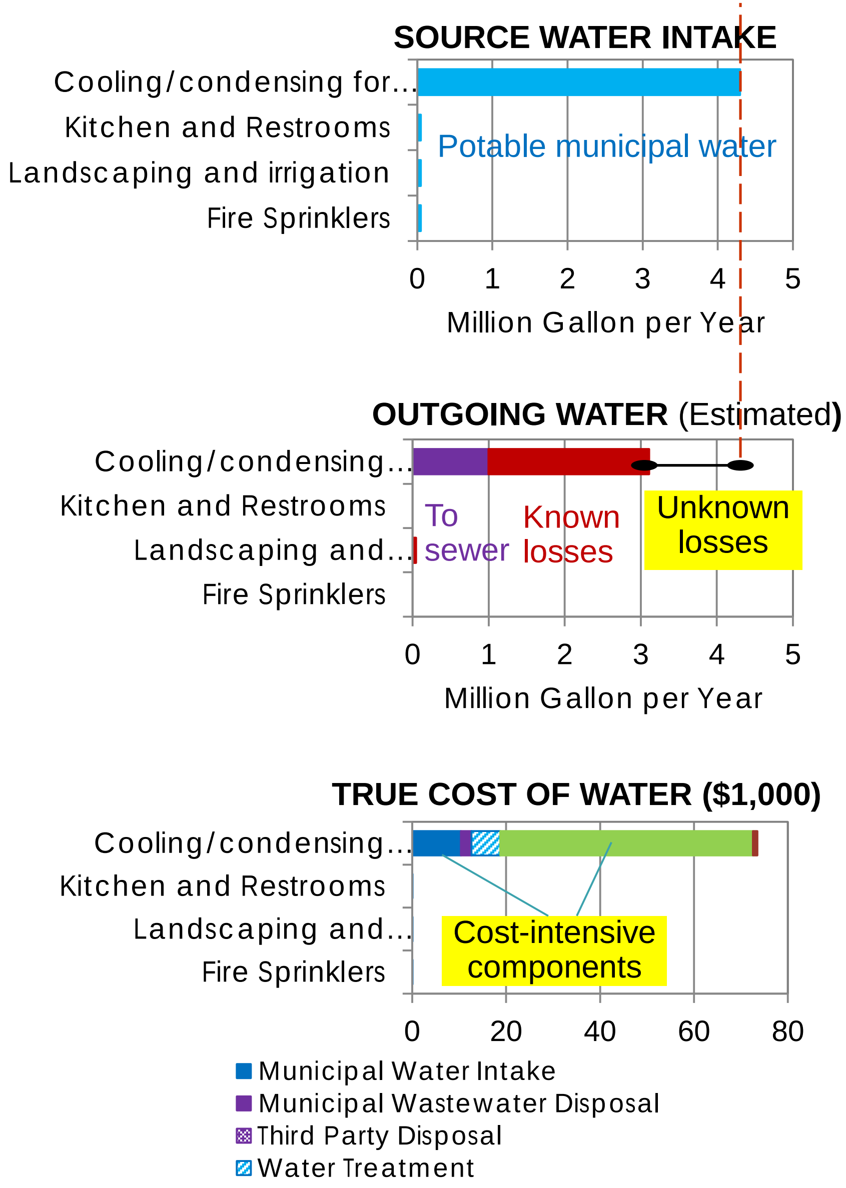
- Cooling and condensing for process operation
- Kitchens and restrooms
- Landscaping and irrigation
- Fire sprinkler system

Plant's water intake and discharge

- Potable municipal water intake; metered
- Discharged to municipal sewer; unmetered*
  *Sewer charges based on % of water intake

Existing submeters

- For cooling system incoming water and blowdown; however, metered data was not recorded => **Data collection challenge**

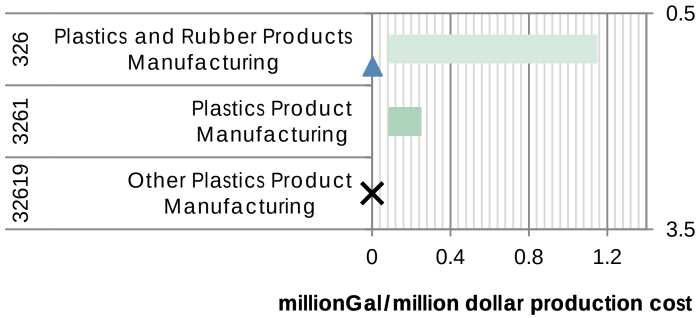


Provided by Saint Gobain North America

Comparison with Industry Average

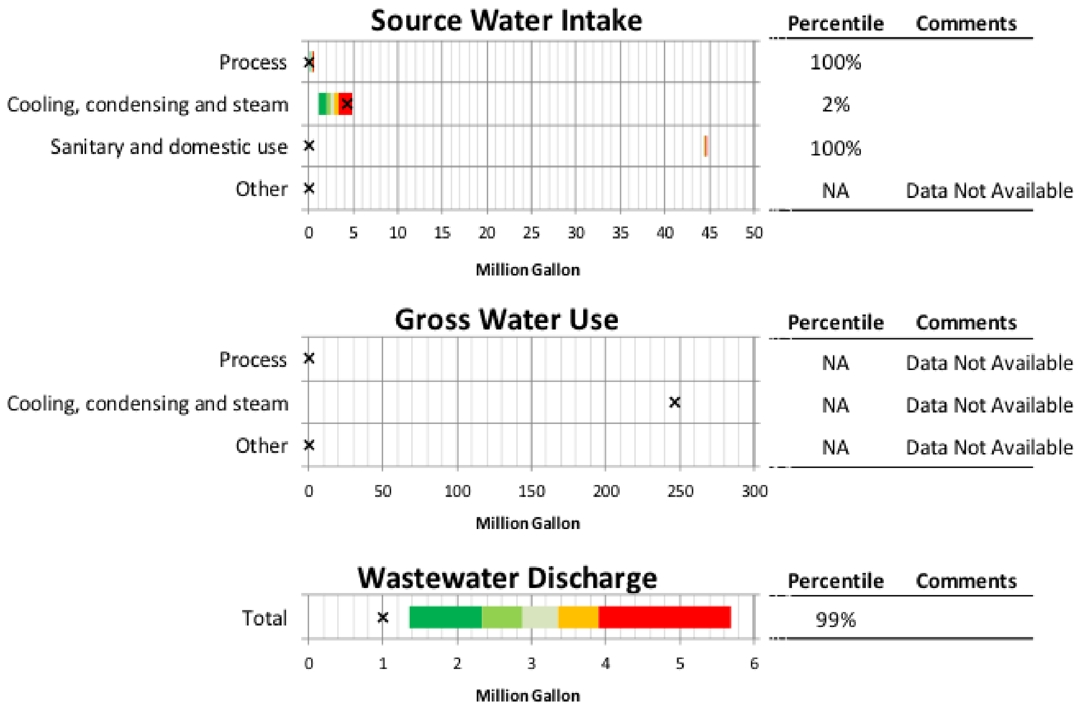
Source Water Intake Benchmark using EIO–LCA data

- CertainTeed facility NAICS code 32619: Other Plastics Product Manufacturing
- There is not a specific industry code for polypropylene siding products



Comparison with Industry Average

- As per our initial findings, the facility performed below average with its peers for the amount of water used in its cooling/condensing processes
- Performed well for using no water in its manufacturing process, and for low amounts of water used in the sanitary and domestic processes
- Scored well for its low wastewater discharge.
- **Sub-metered data is essential to get more reliable results**



Case Study – Beta Testing
Takeaways/Lessons Learned*

Recommendations for the plant

- **Short-term:** Continuously monitor and record all cooling system meters and use this info to check water/sewer bills
- **Long-term:** Connect meters to network so data is uploaded continuously

- Borrow/rent/buy a flow meter to determine non-metered flows such as sewer (DOE Better Plants Equipment Loan program)

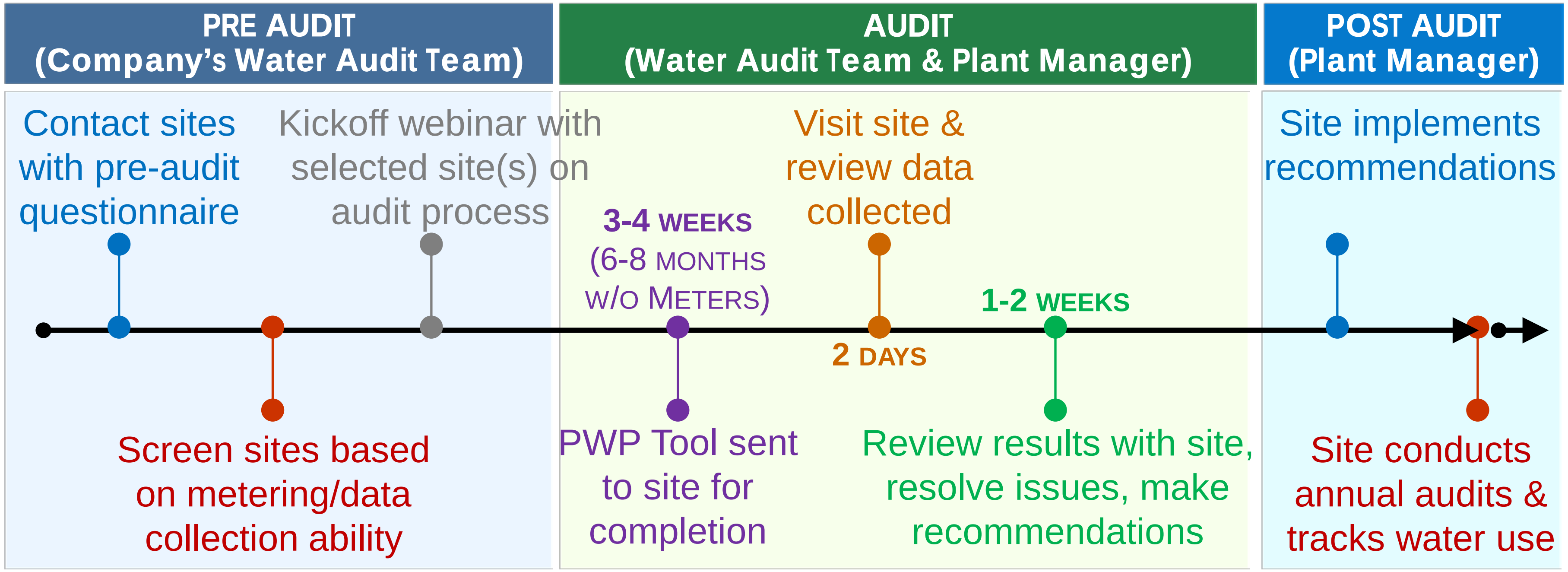
- Consider capturing and treating blowdown for other purposes

PWP Tool motivated the site to effectively use existing meters & invest into installing more meters.

**Provided by Saint Gobain North America*

Case Study – Beta Testing
Takeaways/Lessons Learned*

Recommended process for water audit



**Provided by Saint Gobain North America*

Plant Water Profiler (PWP) Tool: Summary

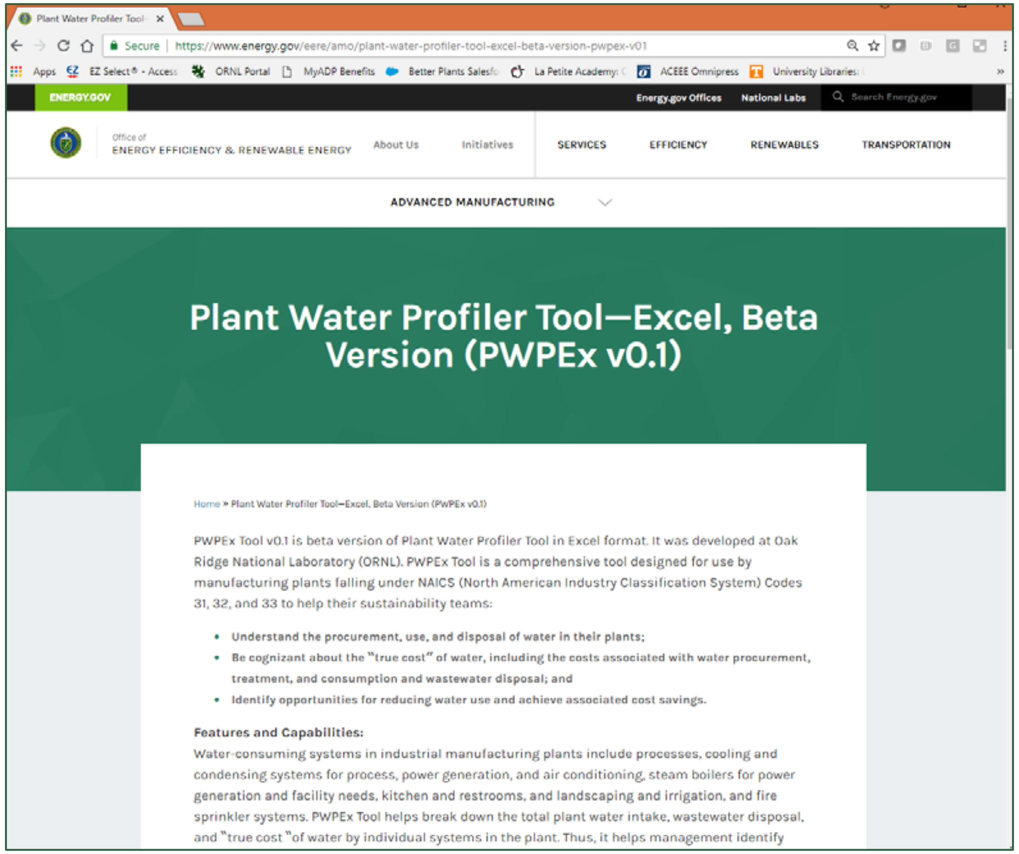
- Benchmarking functionality allows comparison with industry averages, which serves as a motivation to save water.
- The water balance steps quantify the unknown water losses to be eliminated, which are usually low-cost/no-cost measures.
- The true cost of water reveals the hidden costs of using water and identifies cost-intensive systems to help prioritize measures, accordingly.
- The estimate of savings from eliminating losses and maximizing recirculation provides realizable saving estimates from low-cost/no-cost measures.
- The water-efficiency recommendations provide a facility a list of steps to follow to save water and associated costs.

Limitations and Future Work

- The scope of PWP is the facility boundary.
- Good understanding of water flows in the plant needed, especially if submetering is not done on system level.
- PWP doesn’t factor in equipment-related costs, indirect costs, and economic factors (discount rate, inflation).
- It doesn’t account for a company's water-related business risks or impacts because there is no context for the facility’s water use within the watershed.
- It doesn’t account for the indirect embodied energy —i.e., energy used indirectly and offsite during different life stages of water/wastewater systems.
- PWP doesn’t quantify savings from or conduct a cost-benefit analysis of installing water-saving devices and implementing specific measures; it only estimates potential savings associated with reducing water use by eliminating quantified losses and increasing recirculation.

Download PWPEx Tool – Beta Version

https://www.energy.gov/eere/amo/plant-water-profiler-tool-excel-beta-version-pwpex-v01

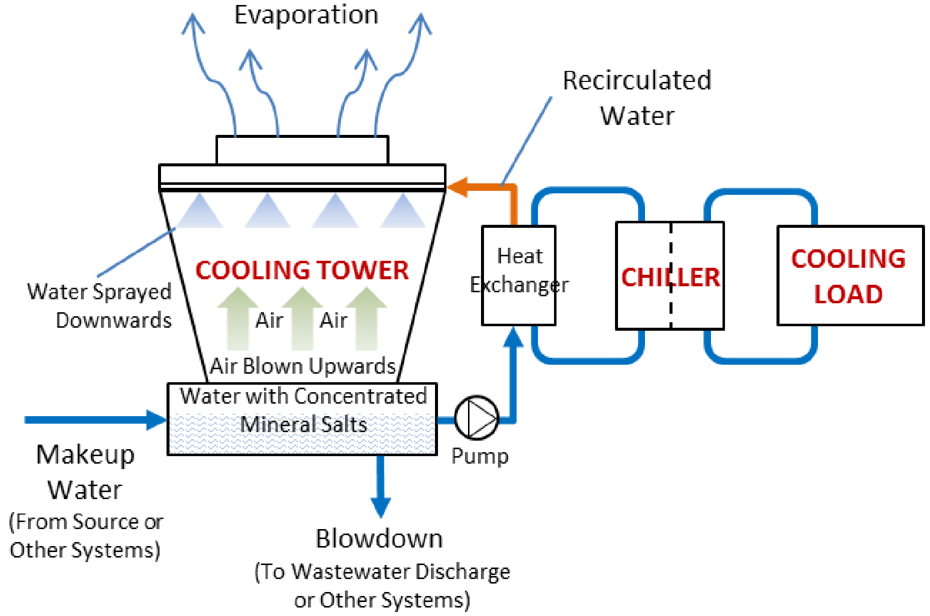


Questions

Sachin Nimbalkar, nimbalkarsu@ornl.gov

Unmetered Facility - Water Use Calculations

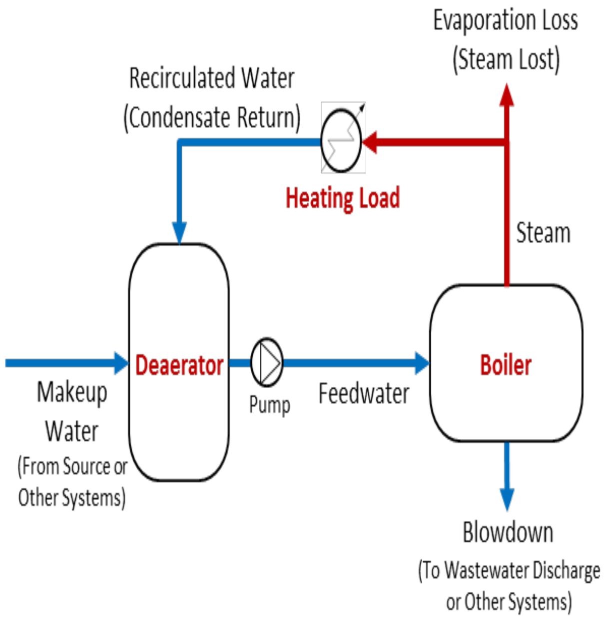
Cooling Tower System



Rules of Thumb

- Load as a Fraction of Chiller Tonnage, the typical range is 0.5 - 0.8
- For "Evaporation Rate per 10°F Temp. Drop," 0.85% is a typical value, and the typical range is 0.65% for moist climate to 1.0-1.2% for very dry climate.
- For "Temp. Drop Across Cooling Tower," typical range 10-15°F

Boiler System



Rules of Thumb

- "Steam Generation Rate per Horsepower" is 34.5 lb/h at 212°F.
- The total annual water use associated with your boiler system(s) can be estimated by knowing either of the following:
  - Softener Performance
  - Steam Generation Rate

References

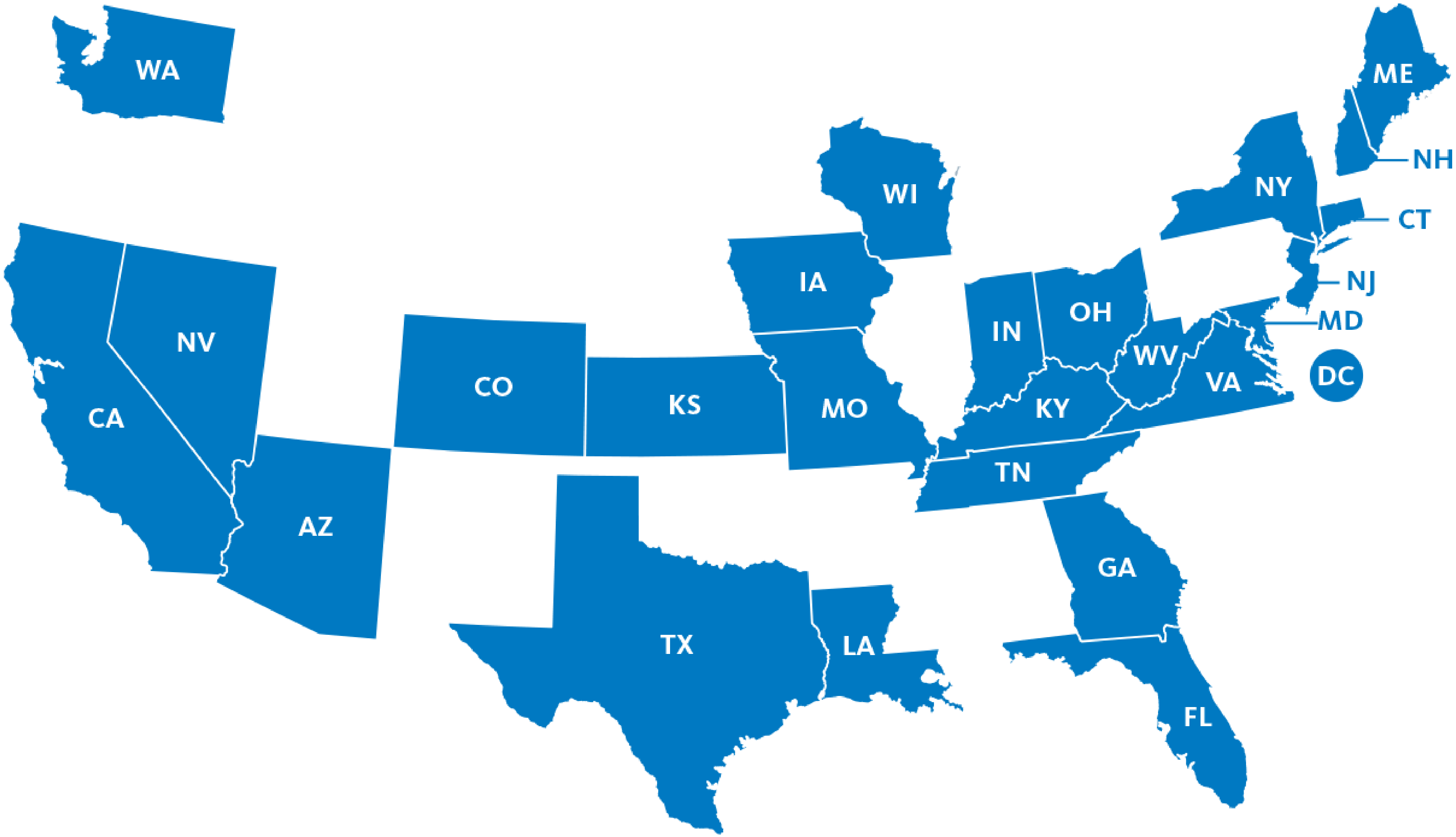
1. “Guidelines for Estimating Unmetered Industrial Water Use,” Brian Boyd, PNNL 2011.
2. “The Water-Energy Nexus, Challenges and Opportunities,” US Department of Energy, June 2014.
3. “Lean & Water Toolkit – Achieving Process Excellence through Water Efficiency,” US Environmental Protection Agency, October 2011.
4. Kimberly et al., “Measuring the Real Cost of Water,” McKinsey Quarterly, March 2013.
5. Gleick et al., “Details of Industrial Water Use and Potential Savings, by Sector,” Pacific Institute, November 2003.
6. “Best Management Practice: Water Management Planning,” Federal Energy Management Program

Hakon Mattson

Anthem Inc.

Better Buildings Summit - Making A Splash

How Anthem Reduced Water Usage by 30% in less than 4 years!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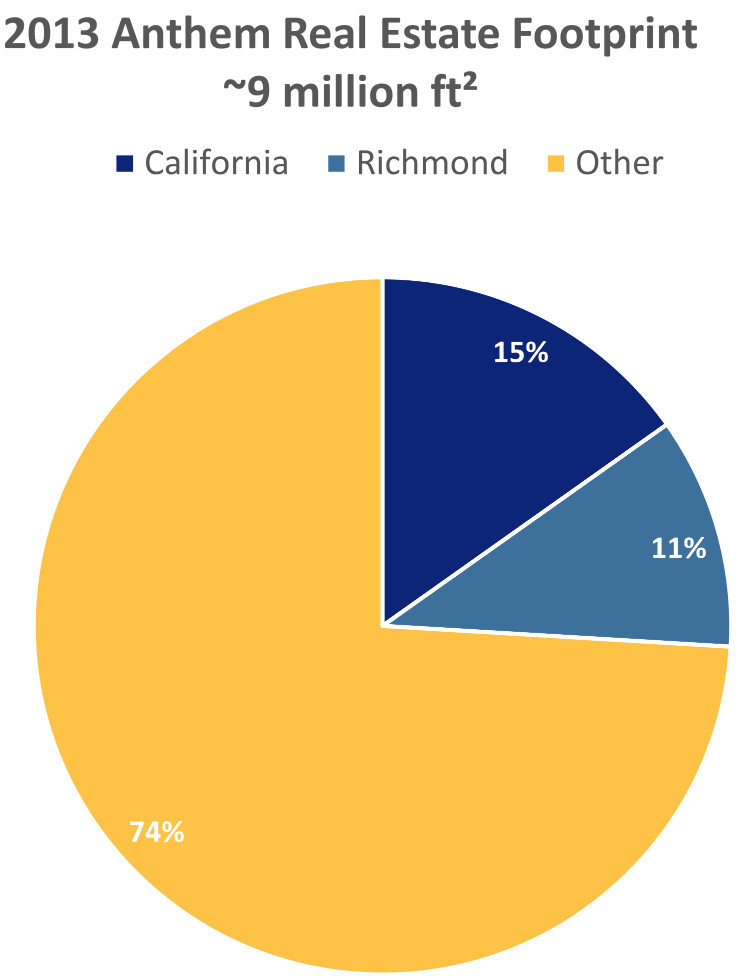
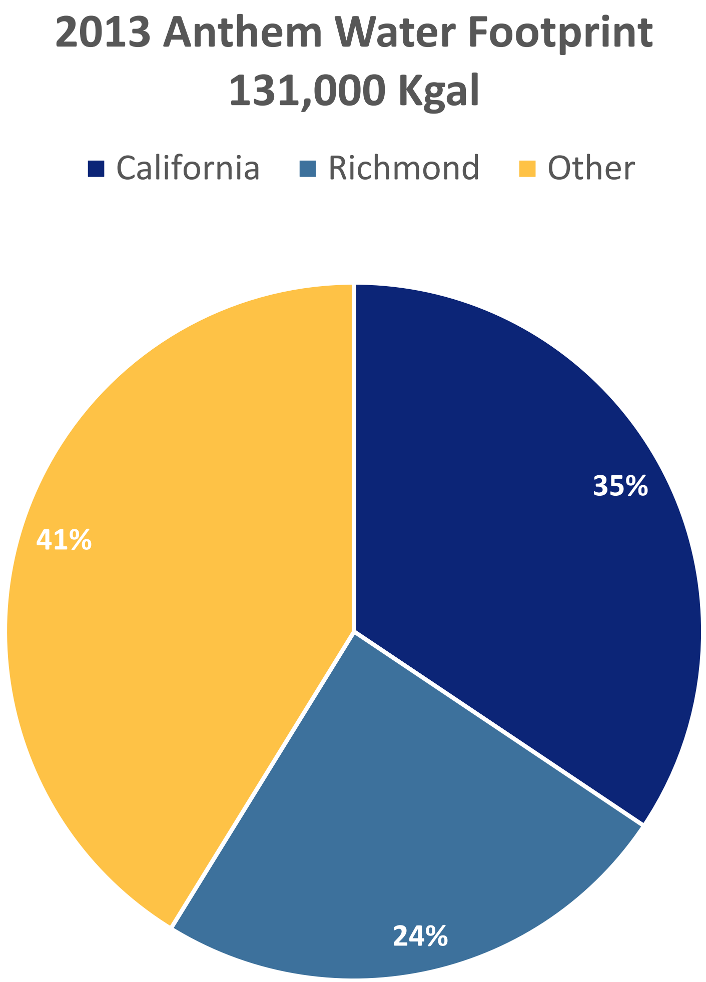
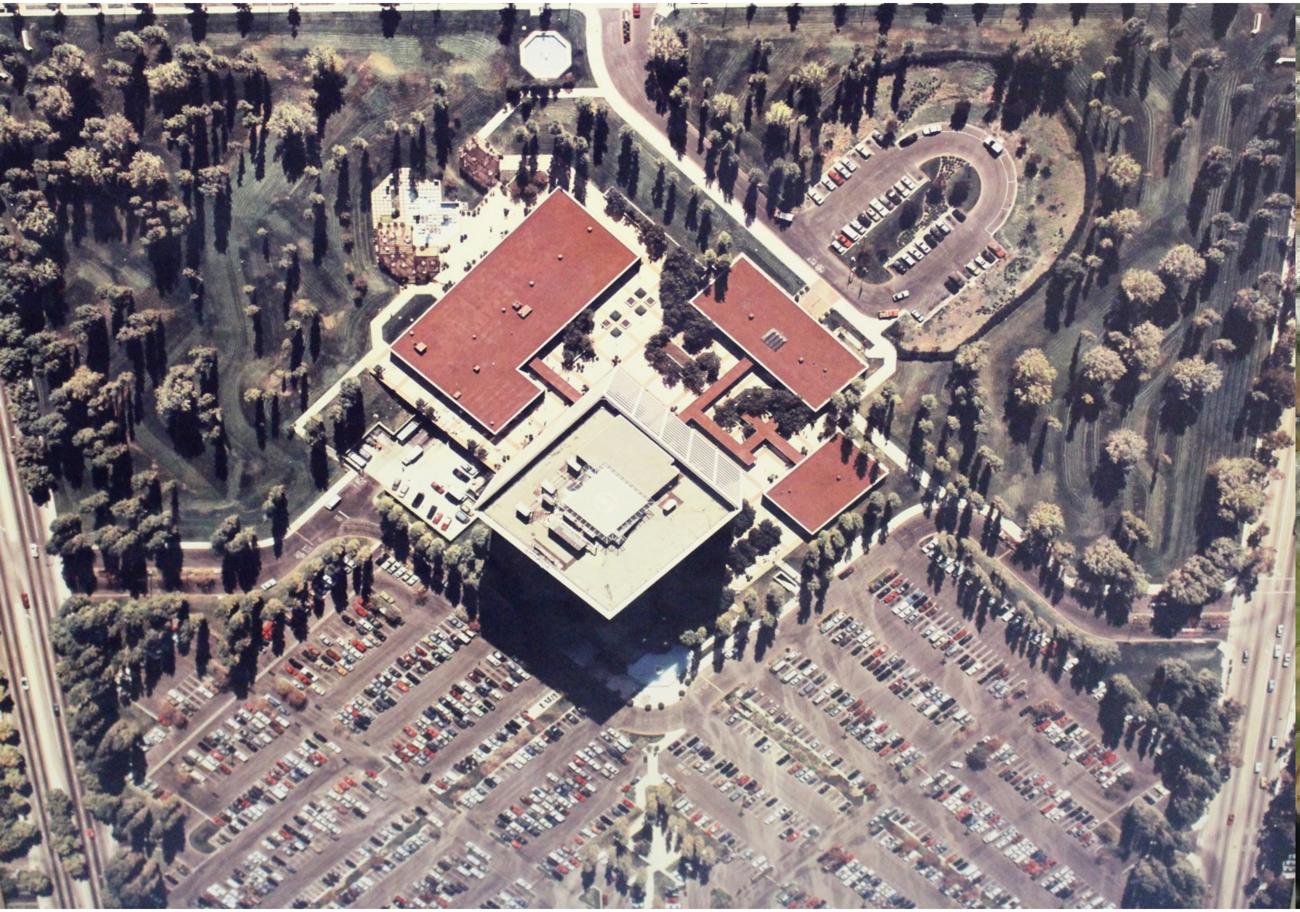
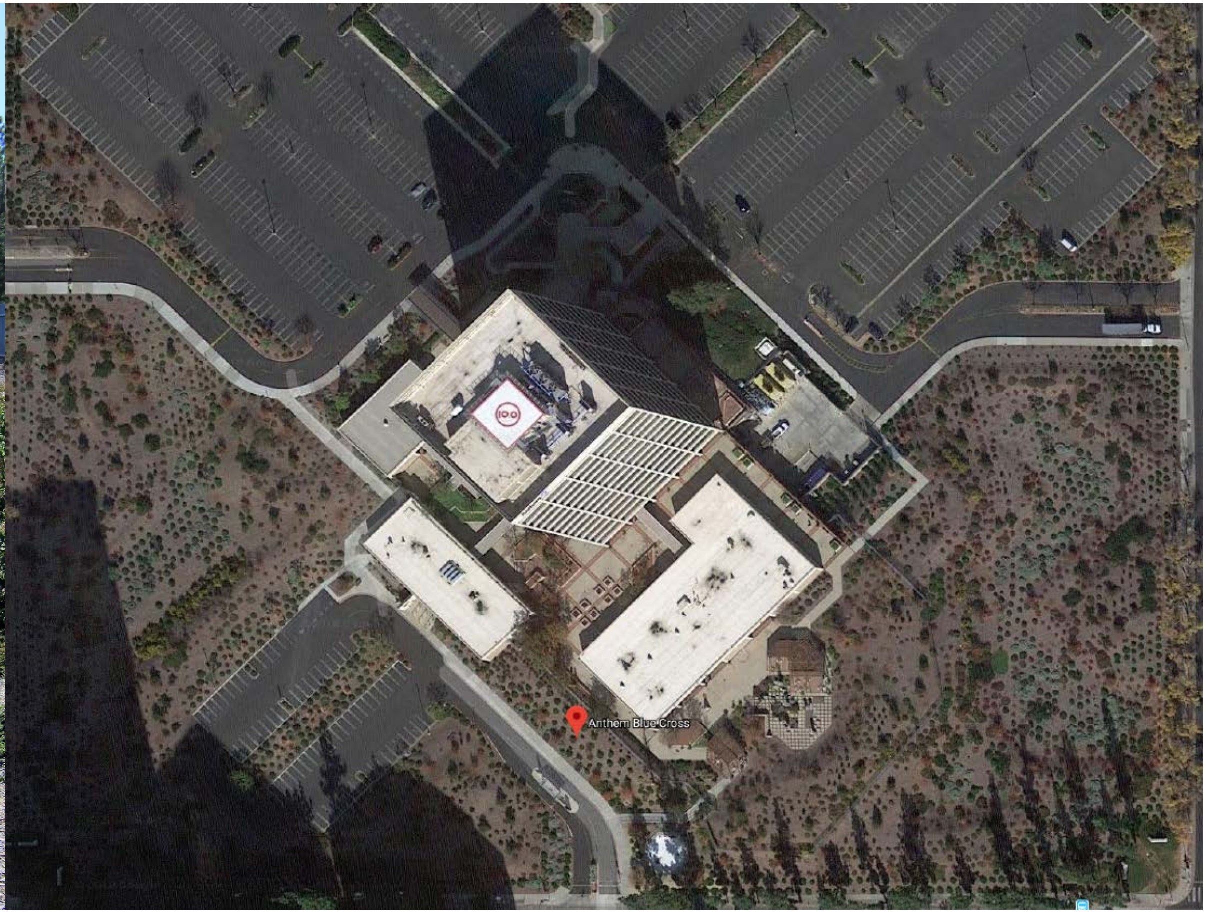
Leadership Commitment
Benchmark Locations
Set Goal
Identify & Prioritize Projects
Dedicated Budget
Measure & Report

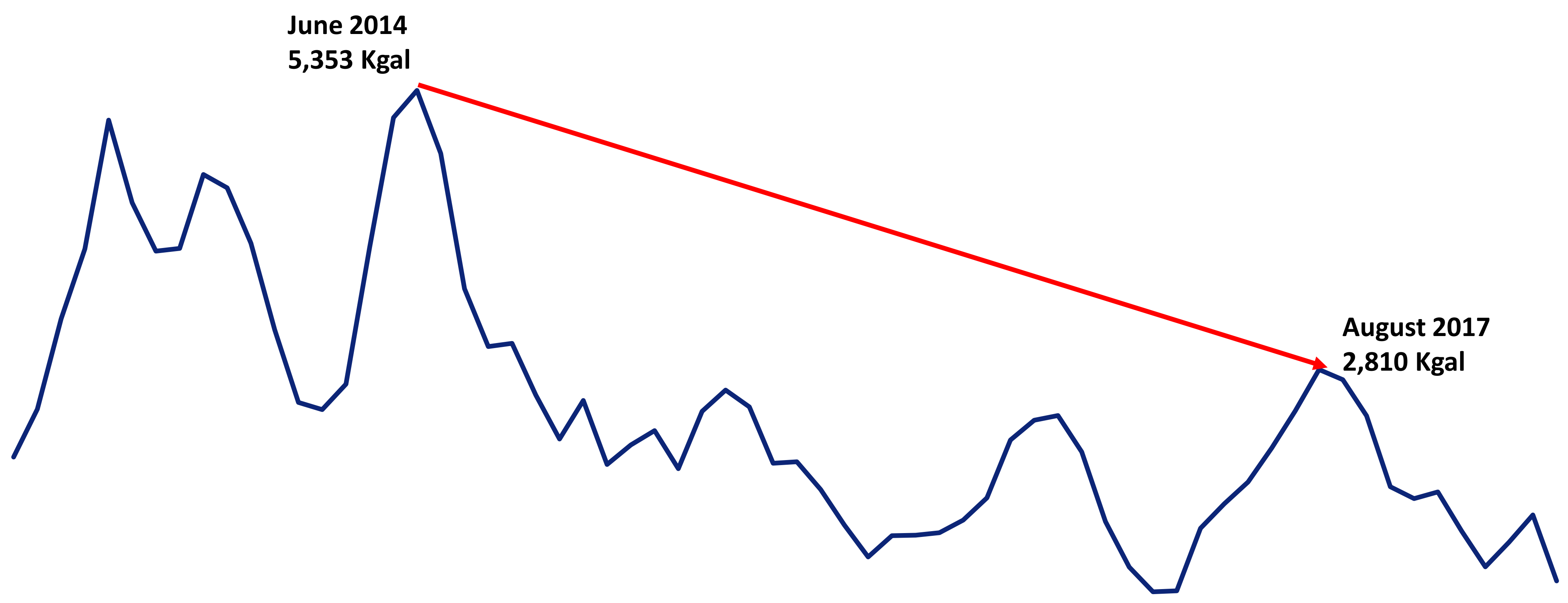

2013 Anthem Real Estate Footprint
~9 million ft²
California
Richmond
Other
15%
11%
74%


2013 Anthem Water Footprint
131,000 Kgal
California
Richmond
Other
35%
24%
41%




Anthem



Anthem Blue Cross



June 2014
5,353 Kgal
August 2017
2,810 Kgal

Otto Van Geet, PE - NREL

NREL

ESIF Data Center Water Use Reductions

NREL Data Center

Showcase Facility

- ESIF 182,000 ft.^{2} research facility
- 10,000 ft.^{2} data center
- 10-MW at full buildout
- LEED Platinum Facility, **PUE ≤ 1.06**
- NO mechanical cooling (*eliminates expensive and inefficient chillers*)

Utilize the bytes and the BTUs!

Data Center Features

- Direct, component-level liquid cooling, 24ºC (75ºF) cooling water supply
- 35-40ºC (95-104ºF) return water (waste heat), captured and used to heat offices and lab space
- Pumps more efficient than fans
- High voltage 480-VAC power distribution directly to high power density 60-80-kW compute racks

Compared to a Typical Data Center

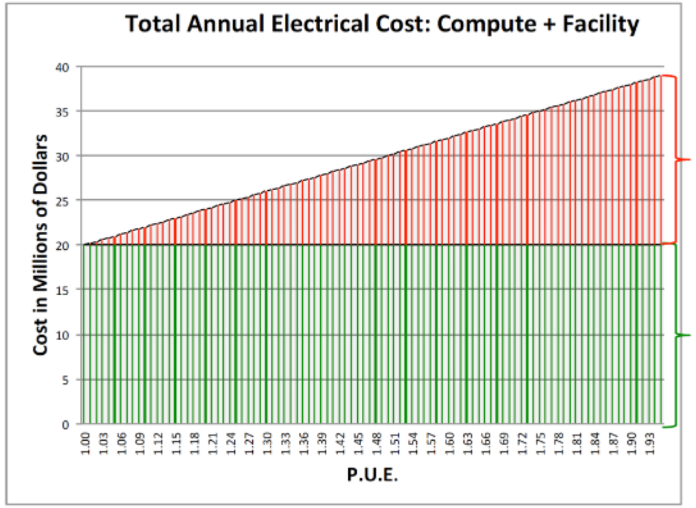
- Lower CapEx—costs less to build
- Lower OpEx—efficiencies save

Integrated "Chips to Bricks" Approach

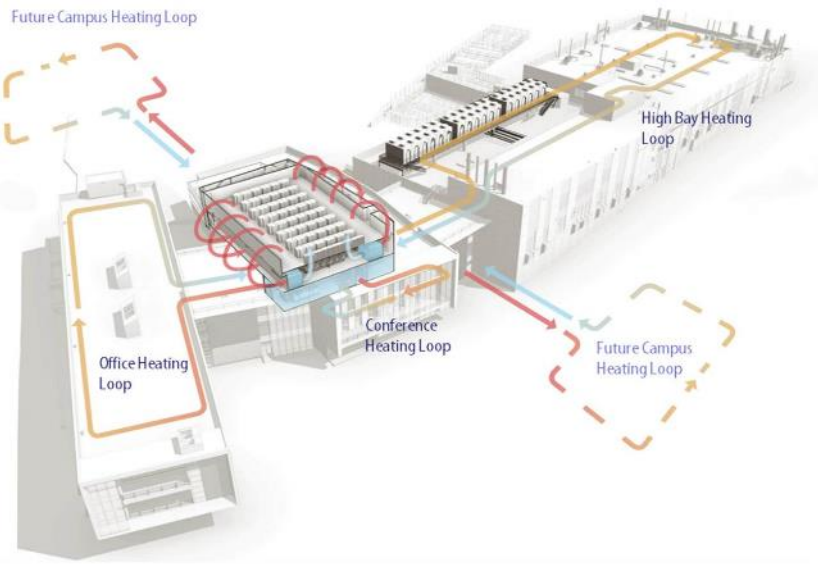
Metrics

$$PUE = \frac{\text{"Facility energy"} + \text{"IT energy"}}{\text{"IT energy"}}$$

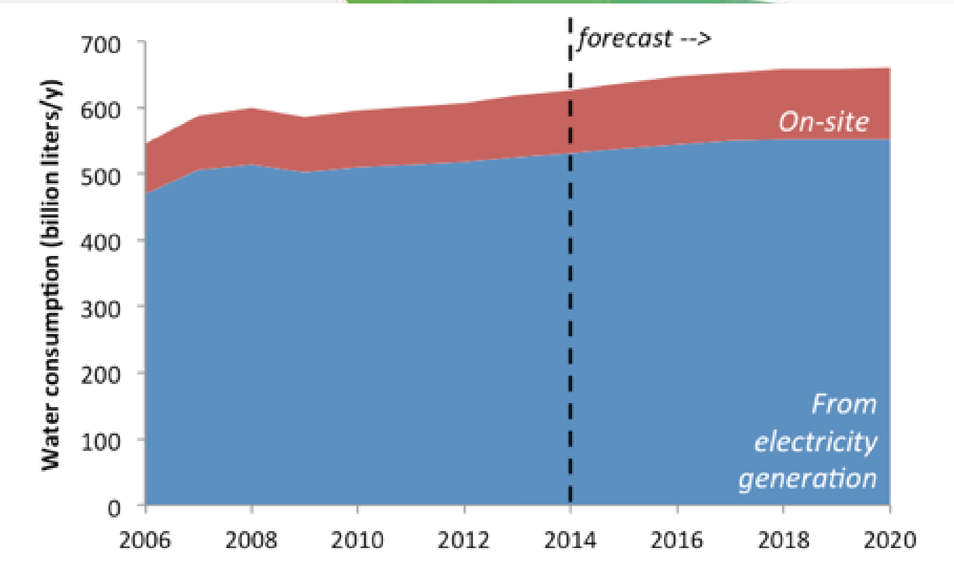
$$ERE = \frac{\text{"Facility energy"} + \text{"IT energy"} - \text{"Reuse energy"}}{\text{"IT energy"}}$$



Assume ~20MW HPC system & $1M per MW year utility cost.



Metrics



$$WUE = \frac{\text{"Annual Site Water Usage"}}{\text{"IT energy"}}$$

the units of WUE are liters/kWh

$$WUE_{SOURCE} = \frac{\text{"Annual Site Water Usage"} + \text{"Annual Source Energy Water Usage"}}{\text{"IT energy"}}$$

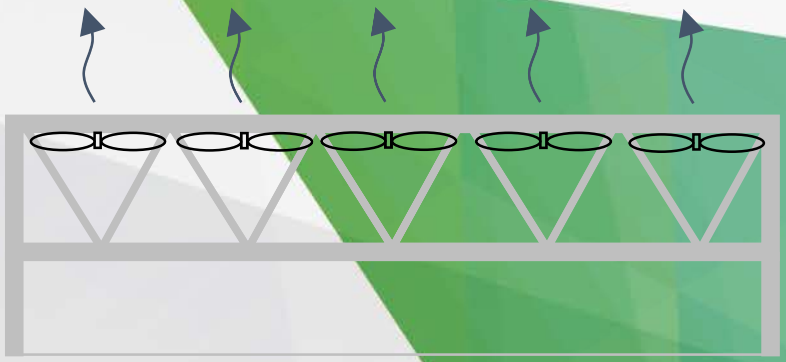
$$WUE_{SOURCE} = \frac{\text{"Annual Site Water Usage"}}{\text{"IT energy"}} + [EWIF \times PUE]$$

where EWIF is energy water intensity factor

Air- and Water-Cooled System Options

Air-Cooled System

- Design day is based on **DRY BULB** temperature
- Consumes no water (no evaporative cooling)
- Large footprint/requires very large airflow rates

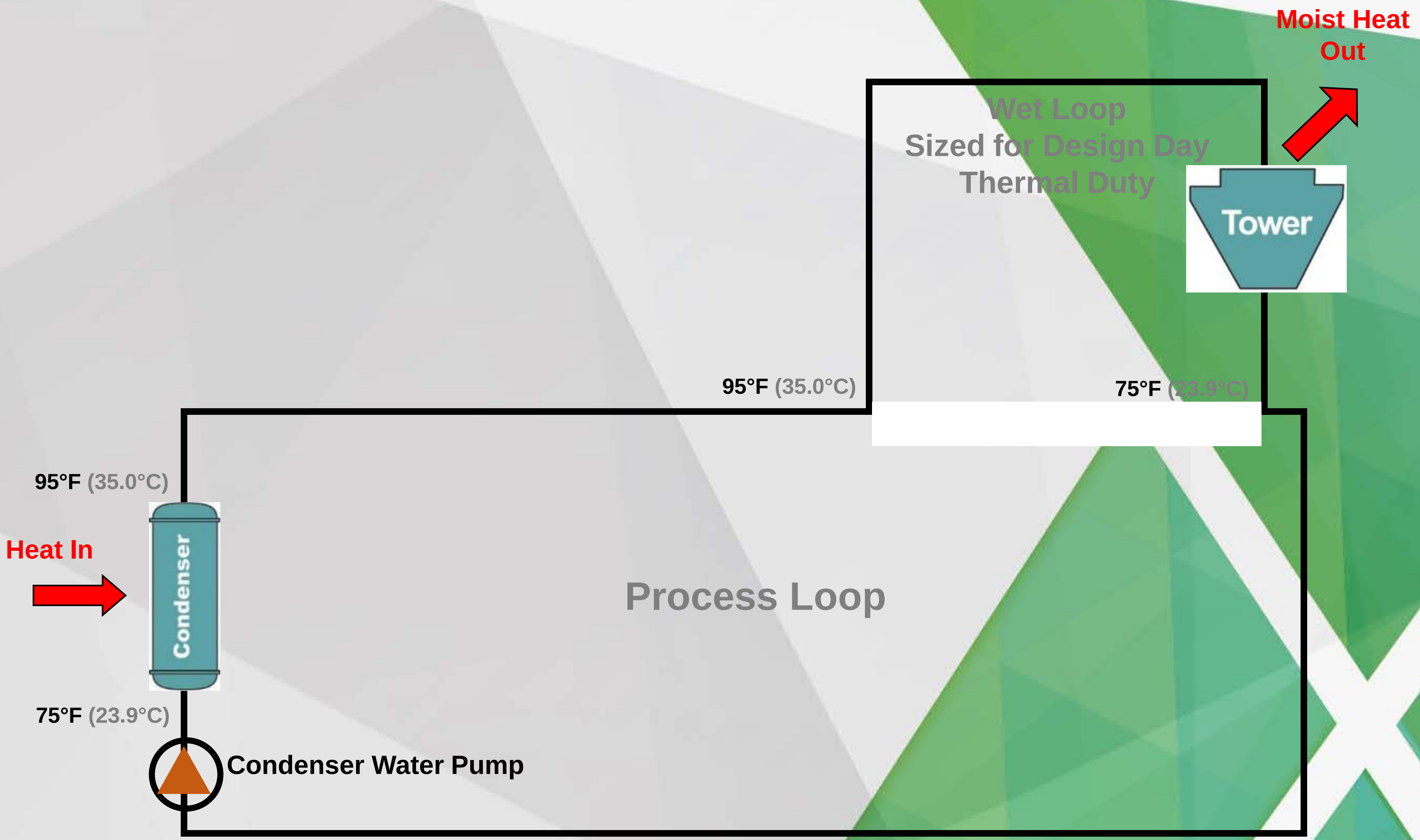


Water-Cooled System

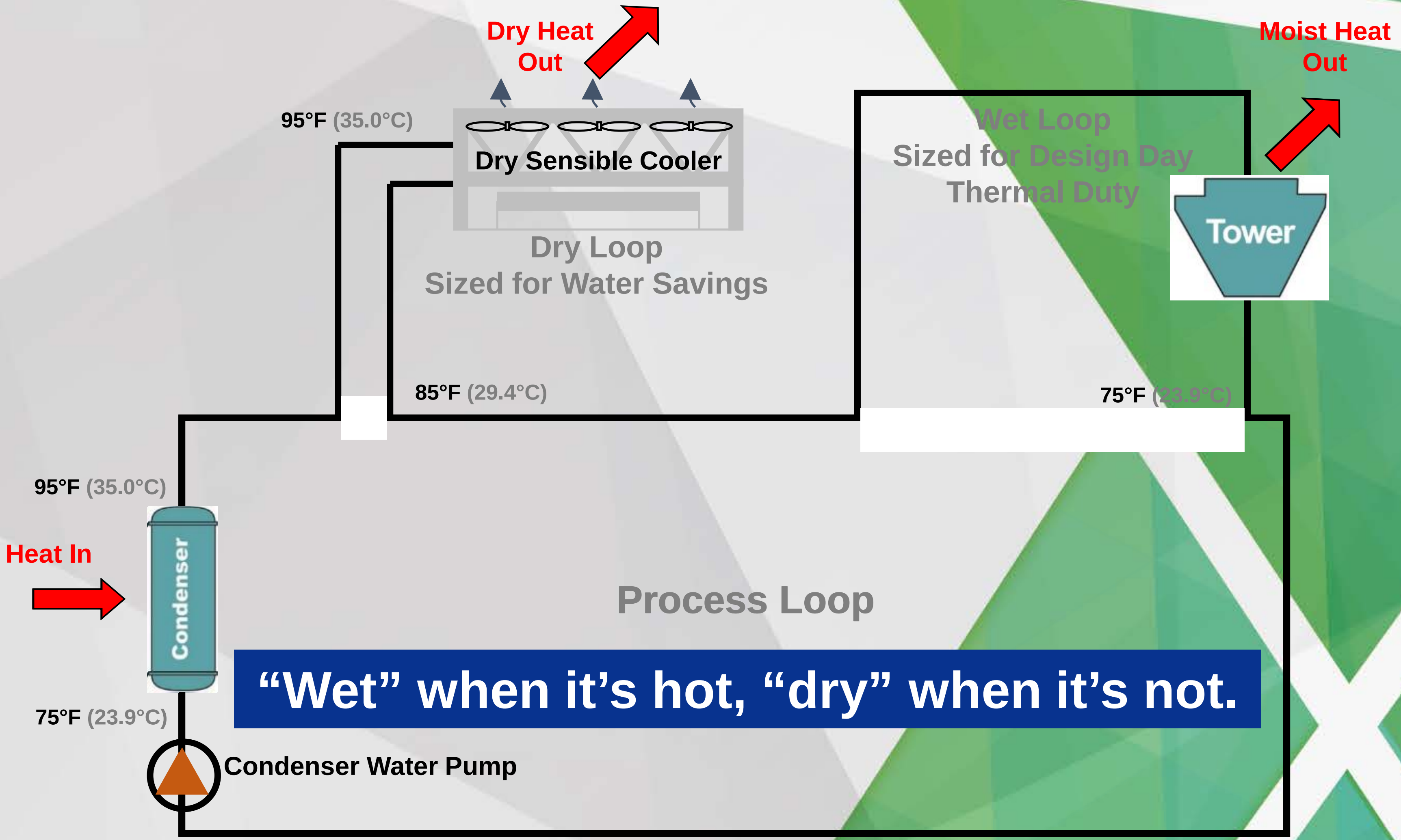
- Design day is based on the lower **WET BULB** temperature
- Evaporative cooling process uses water to improve cooling efficiency
  - **80% LESS AIRFLOW → lower fan energy**
  - Lower cost and smaller footprint.
- Colder heat rejection temperatures improve system efficiency

However, water-cooled systems depend on a reliable, continuous source of low-cost water.

Traditional Wet Cooling System

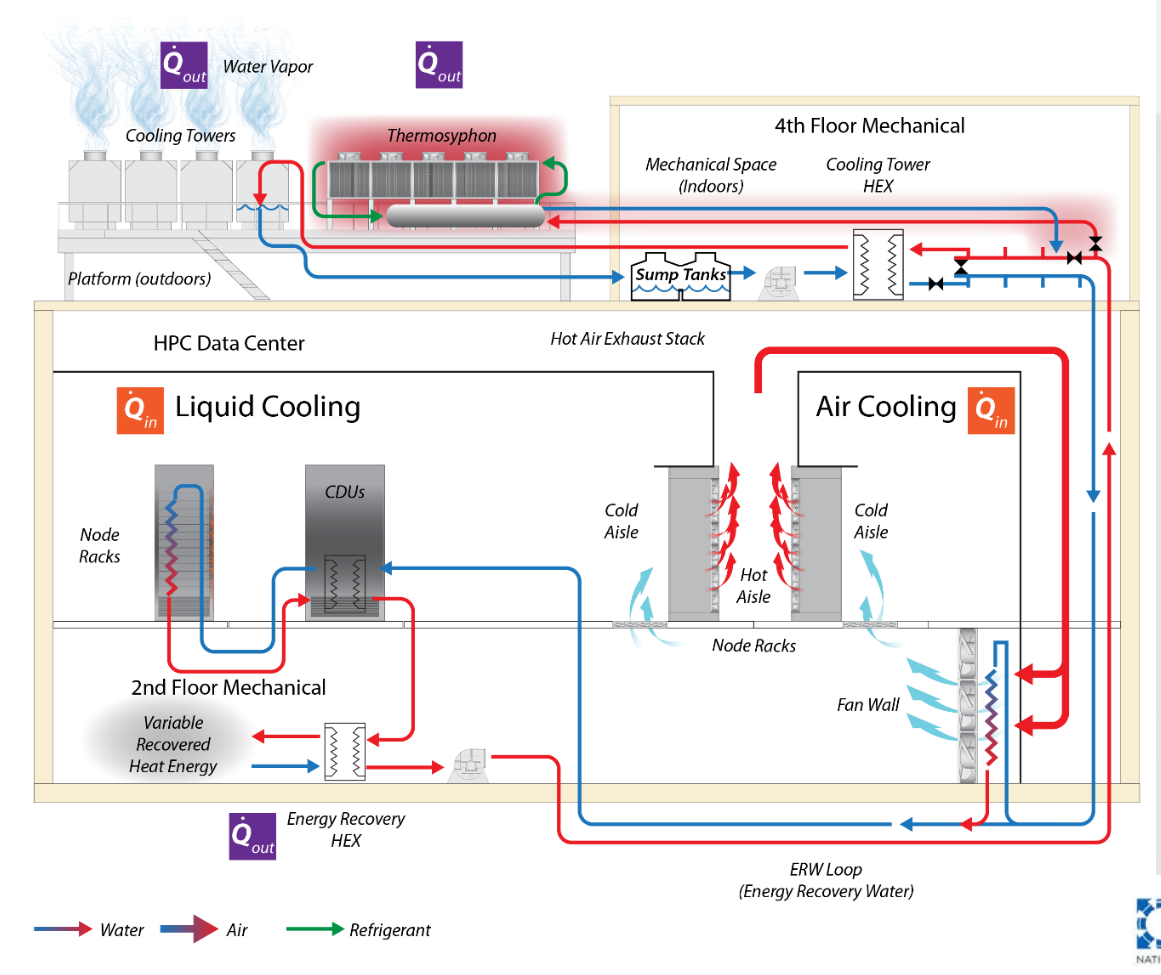


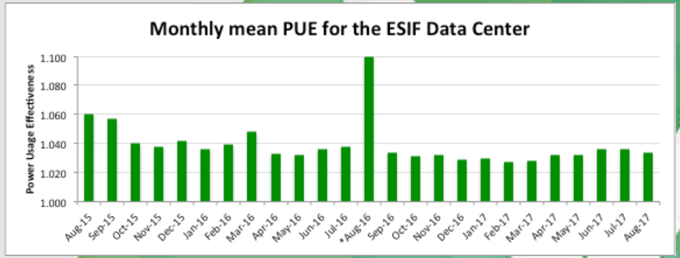
Basic Hybrid System Concept



"Wet" when it's hot, "dry" when it's not.

Improved WUE—Thermosyphon





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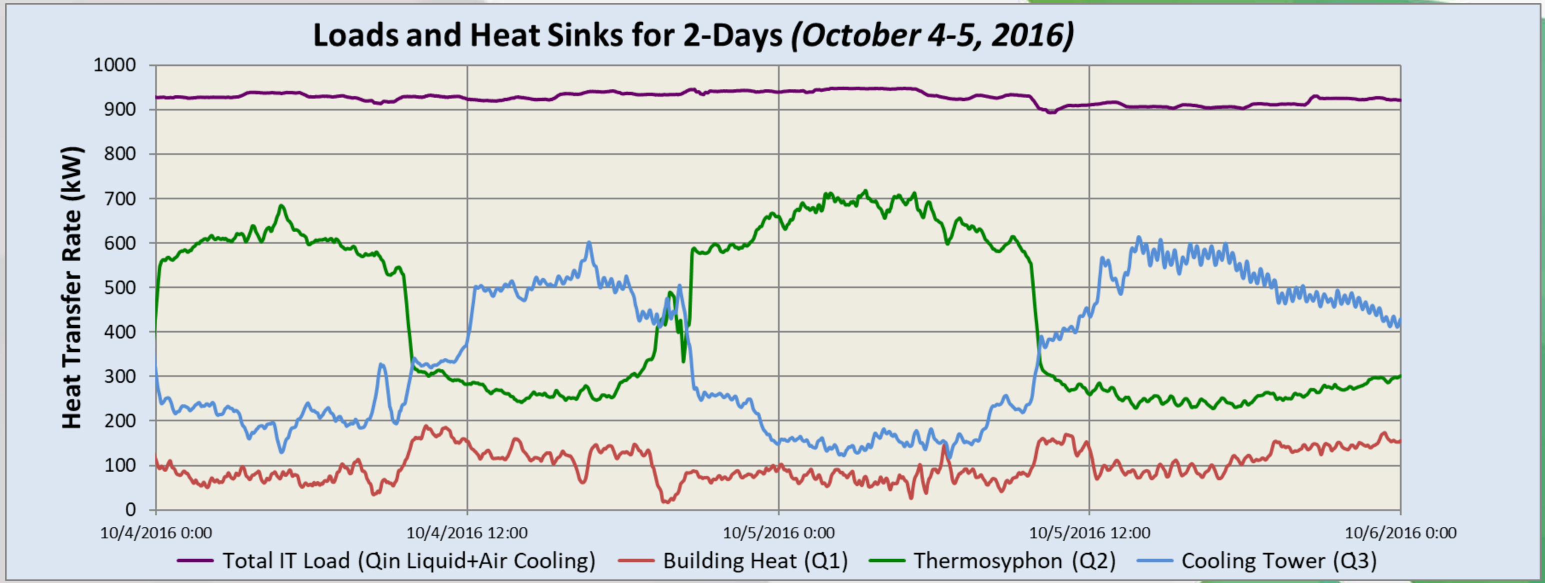
Applications

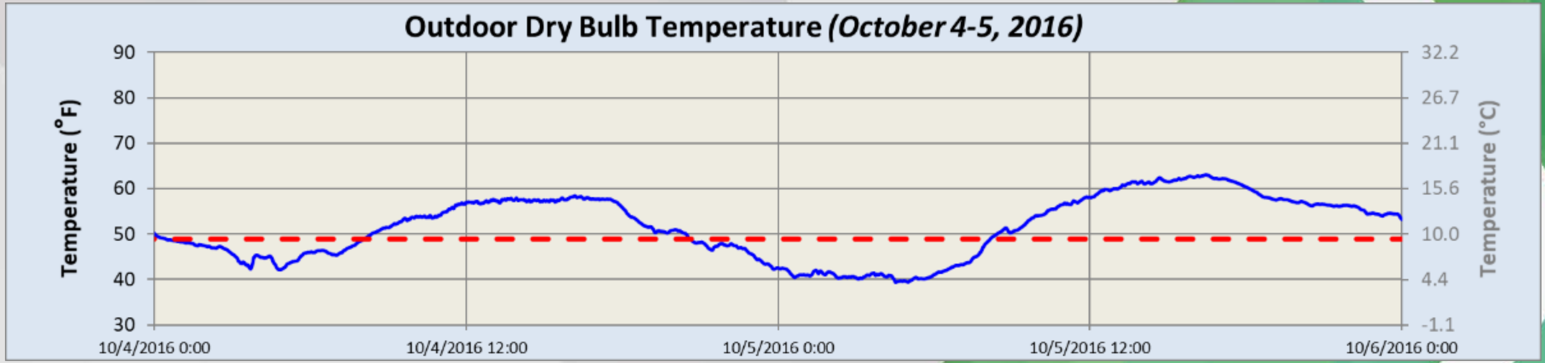
Any application using an open cooling tower is a potential application for a hybrid cooling system, but certain characteristics will increase the potential for success.

Favorable Application Characteristics

- Year-round heat rejection load (24/7, 365 days is best)
- Higher loop temperatures relative to average ambient temperatures
- High water and wastewater rates or actual water restrictions
- Owner’s desire to mitigate risk of future lack of continuous water availability (water resiliency)
- Owner’s desire to reduce water footprint to meet water conservation targets

Sample Data: Typical Loads and Heat Sinks





Data Center Metrics

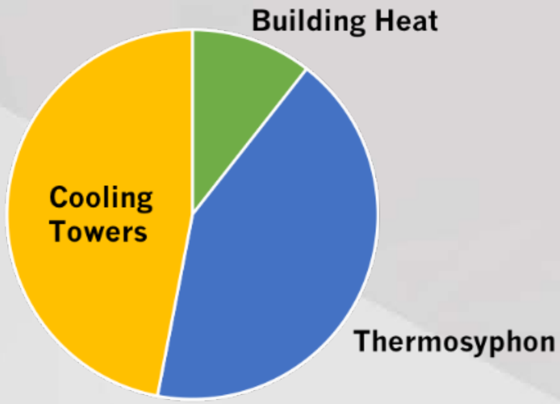
First year of TSC operation (9/1/2016–8/31/2017)

Hourly average IT Load = 888 kW

PUE = 1.034

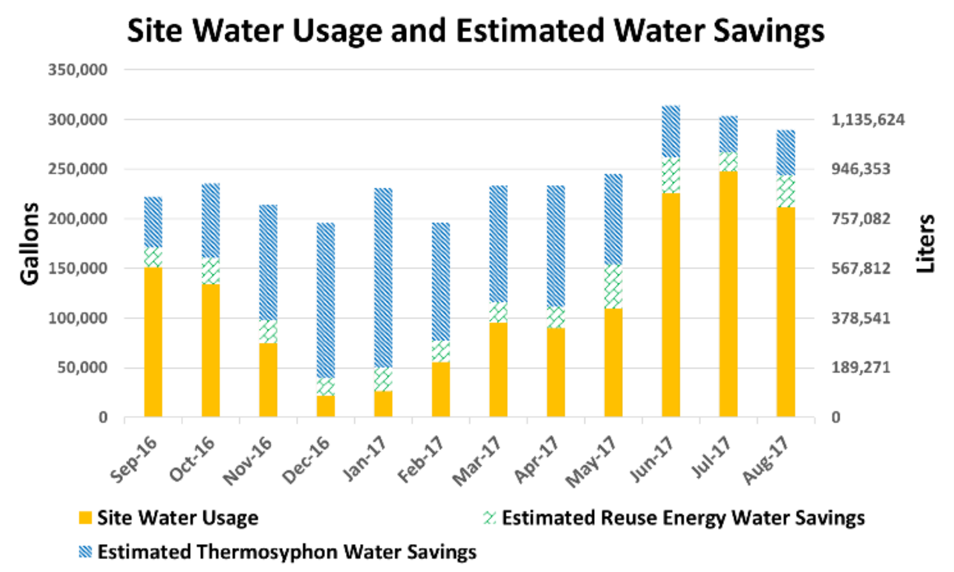
ERE = 0.929

Annual Heat Rejection



WUE = 0.7 liters/kWh

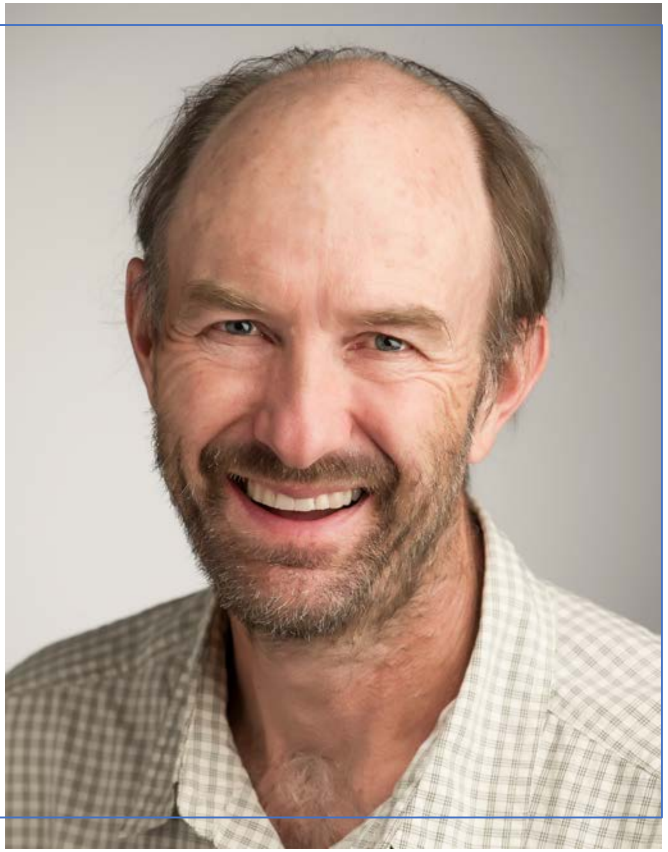
(with only cooling towers, WUE = 1.42 liters/kWh)



WUE_{SOURCE} = 5.4 liters/kWh

WUE_{SOURCE} = 4.9 liters/kWh if energy from 720 kW PV (10.5%) is included

using EWIF 4.542 liters/kWh for Colorado



Otto Van Geet, PE

Principal Engineer, NREL

Otto.vangeet@nrel.gov